THURSDAY, AUGUST 15, 1878

THE COMING ECLIPSE

WHEN I wrote two articles in NATURE a little while ago, discussing the various methods which I thought might with advantage be employed next Monday, I little thought that it would fall to my lot to come to America to take part in the observations. The fates, however, have so ruled it, and here I am, in what was not long ago called the "Great American Desert," but by no means a martyr to science; for, although Rawlins—where I now am—is nearly 7,000 feet high, and near the Rocky Mountain divide; although elk and antelope may be shot within a mile of the town; yet the sluggard is roused at six by the voluminous steam whistle of the railway works: there is a thriving "city" and population.

The energy displayed by the American astronomers is, if possible, greater than I anticipated. There is scarcely a man of note among them who is not now along the totality line which runs from the Yellowstone Park to the Gulf of Mexico. Where the wonderful Union Pacific Railway cuts the line east and west there will be four stations—Rawlins, Separation, Fulmore, and Creton. Along this line will be gathered Professors Newcomb, Harkness, Draper, Watson, with their many assistants. In the middle region, including Denver Central City, and Pike's Peak, will be Professors Young, Holden, Langley, Cleveland Abbe, and General Myer, the chief of the Weather Signal Service. The parties under these are many of them numerous, Prof. Young's camp, for instance, including thirteen persons. In the southern region, at Pueblo and Los Animas, Prof. Hall heads a large party, including Prof. Wright, of Yale, and Prof. Thorpe and Dr. Schuster from the old country.

In all three groups of stations the various kinds of work have been divided in a most judicious manner. In all attempts will be made to obtain the spectrum of the chromosphere and coronal atmosphere in the way suggested in my previous articles; in all the structure of the coronal atmosphere will be carefully inquired into. So far as photographs of the corona are concerned, perhaps the strongest attack will be made by an impromptu party not referred to in the preceding enumeration. On my way here from Cheyenne it was my great good fortune to travel with Prof. Hayden, *facile princeps* among the great geological surveyors of this vast continent. He was on his way to the north, and, as usual, had with him a strong photographic equipment. As his march lies along the line of totality, he will obtain, or at all events endeavour to obtain, a large series of photographs.

It is agreed on all hands that never has such summer weather been known in this locality. Ordinarily the chances, as determined by the officers of the signal service from their registers, are—Northern stations, 80 per cent.; Denver, 60; Pike's Peak, 40; and Los Animas, 80; but here, for the last fortnight, fine mornings have been succeeded by a break-up in the weather in the afternoon, while at Denver matters have been much worse.

A most valuable second series of instructions, written by Prof. William Harkness, of the United States Navy, by direction of Admiral Rodgers, has been published. Of these Sections I., II., V., and VIII. describe such observations as can be made with ordinary apparatus, while the other sections relate mostly to observations which can only be carried out by persons who are able to command expensive apparatus, and who are skilled in astronomy and physics.

This is a most useful following up of the work of organisation undertaken in England for the first time in 1870 and carried out in 1871 and 1875.

Prof. Harkness has freely availed himself of the Instructions compiled for the English Expeditions of those years, and in his carefully written memorandum has given us an opportunity of seeing how the problems have been advanced of late years; he has also collected a valuable series of data which give permanent value to it. I do not think I can do better than refer to some of the more important points touched on in the Instructions.

All the most rapid varieties of lenses in the market suited for use as equatorial cameras are given in the following table, in which the corresponding intensity ratios have been taken from Dallmeyer's catalogue.

Reference No.	Description of photographic objective.	Intensity ratio.[1]	Focal distance of largest lens made.	Diameter of image of sun.	Exposure required for the corona.
			Inches.	Inches.	s. s.
1	Extra quick acting portrait	1/2	5½	0·051	0·3 to 1·6
2	Quick acting portrait ...	1/3½	13½	·126	0·7 to 3·6
3	Ordinary portrait	1/4	24	·224	1·3 to 6·4
4	Portrait and Group (D) ...	1/6	33	·308	2·9 to 14·4
5	Rapid rectilinear	1/8	33½	0·313	5·1 to 25·6

Prof. Harkness points out that "the data from which to determine an approximate value of C for the corona are very limited." He considers that it is probably safe to conclude that, with a clear sky and a moderately high sun, exposures in which the value of C is about 0·002 will give only the prominences and the outline of the moon. When C becomes 0·08 the corona will begin to appear, and will increase in extent as the exposure increases, at least up to the point where C becomes 0·40. Accordingly, the shortest exposure specified in the table above corresponds to $C = 0·08$, and the longest to $C = 0·40$.

If we adopt a lens of thirty-three inches focus an attempt can be made to use the lens for another purpose, "even more important than photographing the corona," that is in the search for intra-Mercurial bodies. Prof. Harkness points out that the magnitude of its intensity ratio enables it to depict faint objects rapidly, and the extent of its angle of view is such as to embrace a field of more than forty degrees. The lens will cover a plate measuring twenty by twenty-two inches, but as it is desirable to keep the apparatus light, plates measuring seventeen by twenty inches, which will suffice to cover a space of thirty-three and a half degrees along the ecliptic, are recommended.

[1] If F is the equivalent focal distance of a photographic objective, d it working aperture, C the exposure constant, whose value depends upon the intensity of the light and the sensitiveness of the chemicals employed, and t the time of exposure required to produce a good negative, then the intensity ratio is $\frac{d}{F}$, and $t = C\left(\frac{F}{d}\right)^2$.

"Assuming the adoption of an equatorial camera twenty inches square, provided with a lens whose intensity ratio is one-sixth and whose focal distance is about thirty-three inches, it yet remains to consider how this apparatus should be managed during a totality lasting only three minutes. As the illumination of different parts of the corona varies greatly, there can evidently be no certainty of geting all the details of the phenomenon unless a series of plates are taken, in which the exposures vary from the shortest possible up to the point where it is certain that an increase of time does not improve the picture. On this account it will be desirable to take as many as six plates, the exposures being, respectively—

3^s, 5^s, 10^s, 20^s, 40^s, and 60^s.

The first four of these plates will receive such short exposures that it is unlikely they will show anything but the corona, and therefore their size should be $4\frac{1}{4}$ by $5\frac{1}{2}$ inches. With the last two plates the case is different. Their size should be 17 by 20 inches, because their longer exposures will probably suffice to bring out upon them any bright points which may exist within their field. A lens such as is here under consideration should depict an eighth-magnitude star in about one minute, but of course the intensity of the sky-illumination during totality will determine the limit of brightness at which faint luminous points will cease to impress themselves upon the negatives, and what this limit may be it is impossible to predict. The necessity for at least two large plates is evident when it is remembered that the image of a small bright point could not be distinguished from an accidental blemish in the film, and it would only be by finding it upon both plates that its true character could be unmistakably recognised. It is exceedingly desirable to determine accurately the maximum exposure that the corona will bear with advantage, and it is hoped that on at least one of the large plates it will prove to be over-exposed."

It has been proposed to photograph the red prominences on a scale of ten seconds of arc to a millimetre. The optical apparatus for the production of such pictures must have an equivalent focal distance of 2062·7 centimetres, or 812·1 inches, and if we take C equal to 0·002, which is probably very near the truth, the value of t for lenses of various apertures are given as follows in the instructions :—

Aperture of objective.	$\frac{F}{d}$	$\left(\frac{F}{d}\right)^2$	Exposure required.	Motion of moon.
Inches.			s.	"
6	135·3	18306	36·6	20·1
8	101·5	10302	20·6	11·3
10	81·2	6593	13·2	7·2
12	67·7	4583	9·2	5·0
15	54·1	2927	5·8	3·2
20	40·6	1648	3·3	1·8
26	31·2	973	1·9	1·0

As a prominence one minute high could scarcely be photographed with a six-inch objective, because twenty seconds of its height would be covered by the advancing moon before the exposure was over, Prof. Harkness thinks it does not seem possible to photograph prominences during eclipses on the scale here contemplated with an aperture much less than ten inches.

The section relating to telescopic observation is very full and complete ; full instructions concerning the structure of the corona are given, and the remark is made that "Since the spectroscope furnishes an efficient means of studying the red prominences at any time, it will be very undesirable to waste a single one of the precious moments of totality in examining them."

To facilitate the work of such astronomers as may desire to search for intra-Mercurial planets with considerable telescopic power, a chart is given showing every star so large as the seventh magnitude in that portion of the heavens which will be occupied by the sun on the 29th of July next. The black circle in R.A. 8h. 36m. Dec. + 18° 39′ indicates the position of the sun. Mercury, Regulus, and Mars will be pretty close together, and probably quite conspicuous during totality, but they are so far to the eastward that only the last-named comes within the limits of the chart. Venus may also be seen, but she will be low in the western sky. While looking for planets, the possibility of discovering a small comet, or a meteor stream, should be borne in mind.

"The corona forms a luminous background upon which the moon's limb is sometimes seen projecting beyond the sun; and a little before totality it is even possible that the complete outline of the moon may become visible. Look for these phenomena, and note the time of their occurrence. It is difficult to assign any reason for the existence of rays, or brushes, of light at the cusps of the sun, but it is said they have been seen. If any such appearances present themselves, they should be carefully scrutinised to ascertain if they change either their position or intensity; and the interior of the telescope should be examined to make sure that they do not originate in reflections, either from the tube or from the lenses."

The instructions as to the use of the spectroscope and polariscope are so full that they deserve reprinting *in extenso*. I shall therefore say nothing about them here except to express my belief that no stone has been left unturned to secure results, if results be possible. Spectroscopically, I suppose Dr. Draper and Prof. Young have the strongest outfit, while, so far as I know, Prof. Harkness is the only one who is equipped for photographing the polarisation of the corona.

For the first time thermo-electric observation forms part of eclipse work. One of the many points of interest here, to me, has been the observatory in which Mr. Edison has been experimenting on his tasimeter. It is truly a very wonderful instrument, and from the observations made last night on the heat of Arcturus, it is quite possible that he may succeed in his expectations. For its extreme delicacy I can personally vouch. The instrument, however, is so young, that doubtless there are many pitfalls to be discovered. Mr. Edison, however, is no unwary experimenter.

So much, then, for the present. The day after to-morrow will find us all busier than ever, and if the weather prove fine I hope I shall have, as in 1870 and 1871, another distinct advance in solar physics to chronicle.

J. NORMAN LOCKYER

Rawlins, Wyoming Territory, July 27